

Research Article

Heart Rate Variability in Patients with Post-infarction Left Ventricular Aneurysm

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Abstract

The parameters of heart rate variability are known to be widely used for screening the occurrence of ventricular arrhythmia in patients with post-infarction left ventricular aneurysm. However, in literature, there are not much data on changes in heart rate variability in patients with post-infarction left ventricular aneurysm depending on different therapeutic approaches, and this issue is not sufficiently studied.

The objective of the research was to study the peculiarities of heart rate variability in patients with post-infarction left ventricular aneurysms depending on therapeutic approach.

Materials and methods. We analyzed heart rate variability of 238 patients with post-infarction left ventricular aneurysm. All patients were divided into 3 groups depending on therapeutic approach: optimal basic therapy, patients who underwent percutaneous coronary interventions and those after coronary artery bypass grafting. All patients underwent 24-hours standard ECG monitoring with the analysis of heart rate variability.

Results. The study showed that heart rate variability of patients with post-infarction left ventricular aneurysm depended on treatment tactics; hypersympathicotonia was typical. The values of the low-frequency range in patients of Group I and Group III constituted $3103 \pm 93.6 \text{ ms}^2$ and $3295 \pm 45.4 \text{ ms}^2$, respectively, which was higher compared to those in the control group and Group II, $p < 0.05$. Parasympathetic influences in patients with post-infarction left ventricular aneurysm were weakened. The analysis of the integral parameters showed that in patients with post-infarction left ventricular aneurysm the autonomous mechanisms of regulation predominated over the central ones. The centralization index was the lowest in patients of Group I and Group II, 2.9 ± 0.3 and 2.3 ± 0.1 , respectively, being lower compared to the control group, $p < 0.05$. The other peculiarities were detected as well.

Conclusions. The parameters of heart rate variability in patients with post-infarction left ventricular aneurysm were found to depend on treatment tactics. The patients with non-surgical treatment tactics had the most unfavorable heart rate variability characteristics. They developed hypersympathicotonia and high humoral regulatory influences. The application of revascularization when treating patients with post-infarction left ventricular aneurysm using percutaneous coronary interventions can reduce the aggressive sympathetic influences, as well as the value of the Baevsky index. Revascularization with the use of coronary artery bypass grafting does not allow optimizing the autonomous imbalance, although it reduces stress index.

Keywords

post-infarction left ventricular aneurysm; heart rate variability; treatment tactics

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Problem statement and analysis of the recent research

Heart rate variability (HRV) was firstly described in 1847, when it was discovered that heart rate (HR) depends on breathing, i.e. increases during inspiration and decreases during exhalation. However, the clinical value of this method was stated only in 1963 when researchers noticed that immediately before the fetal death there are some changes in the length between the electrocardiogram (ECG) complexes prior to changes in HR [2]. HRV has gained more clinical importance in the 80-ies, when it was confirmed that its reduction is a strong and independent predictor of mortality due to myocardial infarction (MI) [4].

Since HRV reflects the balance between the sympathetic and parasympathetic divisions of the autonomic nervous system (ANS) at the level of the sinus node, the imbalance of the indices and data of HRV can be an effective predictor of ventricular arrhythmias and sudden cardiac death which often occur in patients with post-infarction left ventricular aneurysm (LVA). The determination of HRV in patients with chronic heart failure (CHF) is of great importance as well; the decrease in this indicator allows identifying patients with an increased risk of death from cardiovascular causes. The relation between reduced HRV and a tendency to the occurrence of life-threatening arrhythmias as well as complications of IHD was confirmed by many studies [6]. Huikuri H. et al., who analyzed HRV in outpatients, showed that its reduction

indicates a rapid progression of coronary artery disease. The slow recovery of autonomic function after MI is a predictor of a high risk of fatal arrhythmic events [3]. In patients with post-infarction LVA, the determination of HRV is widely used for screening and defining the candidates for implantation of cardioverter defibrillator (ICD) [1, 5, 7]. Higher sympathetic activity and reduced HRV in these patients are known to be a marker of developing ventricular arrhythmias and higher mortality [8]. However, despite the widespread implementation of this method into clinical practice, the study of HRV depending on treatment strategy was not carried out. At the same time, we know that standard basic treatment of post-infarction patients includes a number of drugs that can model both the state of nervous and hormonal regulation of the heart.

The objective of the research was to study the peculiarities of HRV in patients with post-infarction left ventricular aneurysms depending on treatment tactics.

1. Materials and methods

We analyzed HRV of 238 patients with post-infarction LVA. All the patients were divided into 3 groups: Group I included 134 persons with post-infarction LVA who received optimal basic therapy (OBT) only; Group II consisted of 56 patients with post-infarction LVA who underwent percutaneous coronary intervention (PCI) in addition to OBT; Group III included 48 patients with post-infarction LVA after coronary artery bypass grafting (CABG). The control group consisted of 36 patients with past MI without post-infarction LVA. There was no difference in age and gender between patients of the study groups as well as the control group. All patients were treated according to generally accepted standards of care for patients with coronary artery disease in the acute period and in the period of post-infarction scarring. The participants were fully informed about the purpose and the course of the research, and written informed consent was obtained.

All patients underwent 24-hour ECG monitoring. The ECG monitoring was performed by the standard method using the Holter-system "Cardiosens K". We analyzed the following parameters: the low-frequency (LF) waves, ms^2 (0.04-0.05 Hz); the high-frequency (HF) waves, ms^2 (0.15-0.4 Hz); the LF/HF coefficient; the Baevsky stress index (BI). The size and amplitude of different waves allowed estimating the tone of the sympathetic (LF) and parasympathetic (HF) divisions and the efficiency of baroreflex regulation. The LF/HF coefficient reflects the autonomic balance of the organism, the physiological equivalent of which is the interaction between the sympathetic and parasympathetic divisions. The Baevsky index corresponds to the degree of regulatory system tension.

Statistical analysis of the results was performed using a standard software package [9]. The probability of differences between the dependent and independent variants was assessed using the Student's t-test; the difference was considered reliable at $p < 0.05$.

2. Results and Discussion

The analysis showed that in patients with post-infarction LVA main HRV parameters depended on treatment tactics (Table 1).

In patients with post-infarction LVA, significantly longer QT interval was observed. For example, in the control group, QT interval was 418.9 ± 18.3 ms, while in Group I it was 523.3 ± 24.5 ms, $p < 0.05$. In Group II and Group III, it exceeded that in the control group as well. After calculating QT interval considering HR in patients with post-infarction LVA the same patterns were observed. The average value of QTs in the control group was 389.1 ± 16.5 ms, in Group II and Group III it was 437.1 ± 12.8 ms and 456.7 ± 21.1 ms, respectively, $p < 0.05$. In patients with post-infarction LVA and revascularization applying CABG the interval was lower as well; however, the difference was not significant.

The cumulative effects (CE) of the ANS prevailed mostly in patients of Group I and Group III. For example, in patients with post-infarction LVA and non-surgical treatment tactics, this parameter was 5132 ± 665 ms^2 , in Group III it was 4919 ± 125 ms^2 , which was significantly higher compared to patients without post-infarction LVA (the control group), 3592 ± 274 ms^2 , $p < 0.05$. It should be noted that the CE of the ANS in Group II were similar to those in the control group.

When assessing the contribution of each autonomic division in the regulation of HR, we found that in patients with post-infarction cardiosclerosis as well as post-infarction LVA, hypersympathicotonia was typical. For example, the value of the LF range constituted 1753 ± 38.9 ms^2 in the control group, while in Group II, it was 2215 ± 59.8 ms^2 , $p < 0.05$. In patients of Group I as well as patients who underwent CABG, sympathicotonia was even more pronounced, and the values of the LF range constituted 3103 ± 93.6 ms^2 and 3295 ± 45.4 ms^2 , respectively, which was higher compared to those in the control group and Group II, $p < 0.05$. Parasympathetic influences in patients with post-infarction LVA were weakened. For example, the lowest value of HF range was observed in Group II being 436 ± 21.7 ms^2 , which was significantly lower compared to that in the control group, 1073 ± 51.4 ms^2 . The values of HF waves were slightly higher in Group I and Group III; however, they were lower compared to that in patients without post-infarction LVA, $p < 0.05$.

When assessing slow humoral-metabolic influences (very low frequency (VLF) waves), we found their prevalence in patients with post-infarction LVA. These influences were the most characteristic for individuals of Group I (the average value of VLF waves was 1318 ± 39.2 ms^2), which was higher compared to patients with post-infarction LVA who underwent revascularization using PCI and CABG, 1176 ± 24.6 ms^2 and 1056 ± 23.3 ms^2 , respectively, $p < 0.05$. Patients of the control group had lower values of this parameter, $p < 0.05$.

In accordance to the mentioned peculiarities there were changes in the total activity expressed as percentages as well. For example, the LF waves had the highest percentage in the total activity of the autonomic influences on the heart in

Table 1. HRV parameters of patients during the active period of the day(M±m)

HRV parameters	Control group (n=36)	Study groups (n=238)		
		I (n=134)	I (n=134)	I (n=134)
QTc, ms	389.1±16.5	492.3±14.7*	437.1±12.8*	456.7±21.1*
QT, ms	418.9±18.3	523.3±24.5*	444.8±17.3¶	492.7±24.3*
CE, ms ²	3592±274	5132±665*	3828±278	4919±125*
HF, ms ²	1073±51.4	713±43.1*	436±21.7*¶	592±17.4*¶
HF norm, % of TP	29.9±2.2	13.9±1.9*	11.4±1.2*	12.1±1.5*
LF, ms ²	1753±38.9	3103±93.6*	2215±59.8*¶	3295±45.4*
LF norm, % of TP	48.8±2.4	60.1±5.7	57.9±4.3	66.9±3.2*
VLF, ms ²	767±27.1	1318±39.2*	1176±24.6*¶	1056±23.3*¶
VLF norm, % of TP	21.2±1.9	26.0±1.5	30.7±1.7*¶	21.2±1.2¶
LF / HF	1.6±0.12	4.4±0.13*	5.1±0.17*¶	5.7±0.12*¶
SI, units	92.1±3.27	33.8±1.12*	55.4±2.19*¶	68.4±3.38*¶
CI	3.9±0.2	2.9±0.3*	2.3±0.1*	3.7±0.4

Note.

* - statistically significant difference between the indicators in Group I and Group II, $p < 0.05$

patients with post-infarction LVA. In Group III, their value reached the level of $66.9 \pm 3.2\%$, which significantly exceeded the similar parameter in patients of the control group, $p < 0.05$. The relevant values of Group I and Group II were higher (compared to the control group) as well; however, the difference was not significant, although the percentages of these waves in patients with post-infarction LVA exceeded 50%.

The percentage values of the VLF waves in the total value of the autonomic influences on the heart prevailed in Group II, where they reached $30.7 \pm 1.7\%$ being significantly higher compared to the control group and Group I, $21.2 \pm 1.9\%$ and $26.0 \pm 1.5\%$, respectively, $p < 0.05$. Slow humoral-metabolic influences were the lowest in patients who underwent CABG constituting $21.2 \pm 1.2\%$, which almost did not differ from the values of patients without post-infarction LVA.

The analysis of the integral parameters showed that in patients with post-infarction LVA the autonomous mechanisms of regulation predominated over the central ones. The level of total tension was higher in all study groups mainly due to the high activity of sympathetic regulation (mainly the suprasedgmental divisions). For example, the centralization index (CI) was the lowest in patients of Group I and Group II, 2.9 ± 0.3 and 2.3 ± 0.1 , respectively, being lower compared to the control group, $p < 0.05$. The indicators of the Baevsky index or stress index (SI) in patients with post-infarction LVA were lower characterizing the high activity of the sympathetic division. In the control group, the parameter was 92.1 ± 3.27 units, while in Group I it was the lowest (the worst) and constituted 33.8 ± 1.12 units, $p < 0.05$. In other study groups the values of the Baevsky index were slightly higher, although significantly lower compared to those in the control group.

Similar patterns were found when analyzing HRV parameters during the passive period of the day (Table 2). In patients with post-infarction LVA both the predominance of

the sympathetic influences on the heart, and the high activity of hormonal influences were observed. For example, in the control group, the value of LF waves was $1346 \pm 42.8 \text{ ms}^2$, while in Group I, Group II and Group III – $2745 \pm 62.8 \text{ ms}^2$, $1785 \pm 32.8 \text{ ms}^2$ and $2456 \pm 31.3 \text{ ms}^2$, respectively, $p < 0.05$. The parasympathetic influences predominated in Group I and the control group.

In Group I and Group III, the frequencies in the spectrum of VLF autonomous influences prevailed those in the control group, $1181 \pm 24.9 \text{ ms}^2$, $1512 \pm 24.6 \text{ ms}^2$ and $1043 \pm 28.4 \text{ ms}^2$, respectively, $p < 0.05$. In Group II, the mentioned parameter was significantly lower compared to patients without post-infarction LVA, $871 \pm 17.2 \text{ ms}^2$, $p < 0.05$. In accordance with the data obtained in the passive period of the day the basic integral indicators changed as well. Thus, the CI and SI reflected the predominance of the sympathetic influences on the heart, as well as the predominance of the peripheral regulation over the central one.

3. Conclusions

Thus, HRV analysis showed that in patients with post-infarction LVA sympatheticotonia and a high activity of humoral influences are typical; the peripheral influences predominate over the central one during both the active and passive periods of the day. The persons with post-infarction LVA have significantly longer QT intervals.

HRV parameters were found to depend on treatment tactics. The patients with post-infarction LVA and non-surgical treatment tactics have the most unfavorable HRV characteristics. They develop hypersympathicotonia and high humoral regulatory influences. The application of revascularization when treating patients with post-infarction LVA using PCI can reduce the aggressive sympathetic influences, as well as the

Table 2. HRV parameters of patients during the passive period of the day (M±m)

HRV parameters	Control group (n=36)	Study groups (n=238)		
		I (n=134)	I (n=134)	I (n=134)
QT, ms	452.7±19.6	512.6±16.8*	468.4±14.6	489.6±18.4
QTc, ms	422.4±15.8	501.5±12.4*	446.2±15.7¶	443.1±17.5¶
CE, ms ²	3235±226	4852±463*	3234±245¶	4439±235*
HF, ms ²	846±45.6	926±37.5	578±19.4*¶	471±18.1*¶
HF norm, % of TP	26.2±2.3	19.1±1.6*	17.9±1.8*	10.6±1.4*¶
LF, ms ²	1346±42.8	2745±62.8*	1785±32.8*¶	2456±31.3*¶
LF norm, % of TP	41.6±3.1	56.6±4.5*	55.2±4.9*	55.3±4.5*
VLF, ms ²	1043±28.4	1181±24.9*	871±17.2*¶	1512±24.6*¶
VLF norm, % of TP	32.3±2.4	24.4±1.8*	26.9±1.6	34.1±3.1¶
LF/HF	1.6±0.12	3.0±0.17	3.1±0.14*	5.2±0.16*¶
SI, units	135.9±4.2	57.5±2.1*	69.4±2.4*¶	84.6±3.8*¶
CI	2.1±0.3	2.6±0.4	2.7±0.2	1.9±0.2

Note.

* - significant difference between the control group and study groups, $p < 0.05$;

¶ - significant difference between Group I and other study groups, $p < 0.05$

value of the Baevsky index. Revascularization with the use of CABG in patients with post-infarction LVA does not allow optimizing the autonomous imbalance, although it reduces SI.

4. Prospects for further research

The interpretation of the obtained results is limited by various schemes of treatment in different groups as well as different terms of LV revascularization. A perspective direction of the research is the study of the rhythm turbulence in patients with post-infarction LVA and different treatment tactics.

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